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TITLE: **FOAMED IGNITER FOR USE IN AUTOMOTIVE AIRBAG INFLATORS**

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FOAMED IGNITER FOR USE IN AUTOMOTIVE AIRBAG INFLATORS

BACKGROUND OF THE INVENTION

This invention relates generally to an igniter composition for use in an inflator device for an inflatable restraint system. More particularly, this invention relates to a foamable igniter composition that upon being heated to a predetermined temperature forms a foamed igniter substance.

It is well known to protect a vehicle occupant using a cushion or bag, e.g., an "airbag cushion" that is inflated or expanded with a gas when a vehicle experiences a sudden deceleration, such as in the event of a collision. Such airbag restraint systems normally include: one or more airbag cushions, housed in an uninflated and folded condition to minimize space requirements; one or more crash sensors mounted on or to the frame or body of the vehicle to detect sudden deceleration of the vehicle; an activation system electronically triggered by the crash sensors; and an inflator device that produces or supplies a gas to inflate the airbag cushion. In the event of a sudden deceleration of the vehicle, the crash sensors trigger the activation system which in turn triggers the inflator device which begins to inflate the airbag cushion in a matter of milliseconds.

Many types of inflator devices have been disclosed in the art for use in inflating one or more inflatable restraint system airbag cushions. Many prior art

inflator devices include a solid form of gas generant material which is burned to produce or form gas used in the inflation of an associated airbag cushion.

Such inflator devices tend to involve a chain of reactions of materials, e.g., pyrotechnics, contained within an inflator device to produce or generate an inflation medium, e.g., inflation gas, to result in the deployment of an airbag cushion. For example, such devices commonly employ a squib or initiator that is electronically ignited when a collision is sensed. The discharge from the squib in turn ignites an igniter material generally positioned in close proximity to the squib. The igniter material desirably burns relatively rapidly, with a large caloric output, such as to desirably uniformly ignite a supply of gas generant material. The gas generant material in turn burns to produce or form gas such as is directed into an associated airbag cushion to effect inflation thereof. In general, the ballistic properties of a gas generant material are controlled by the shape (usually tablets or wafers) and burn rate of the gas generant material.

As will be appreciated, rapid and repeatable ignition of a gas generant material is critical to providing inflator devices that enable an airbag cushion to reliably deploy in the very short periods of time associated with vehicle occupant passive restraint systems. For example, inflator designers typically require the period of time following activation of the system until gas is expelled from an inflator to be less than 3 milliseconds.

Inflator designs that attempt to incorporate, by simply blending or mixing together, an igniter powder with gas generant tablets, wafers or other gas generant particle shapes have generally not proven successful. In particular, igniter powders in such inflator designs tend to be susceptible to migration away from the squib and gas generant particles over time. Consequently, such designs may experience unacceptable delays and produce or result in less than optimal occupant protection.

In view thereof, conventional inflator devices have commonly included some form of igniter material packaging to ensure the proper placement and positioning of the igniter material within the inflator device to effect desired ignition and reaction of the associated gas generant material. More specifically, it is common for inflator devices to include a powdered igniter material that is packaged within a separate container in close proximity to the squib and the gas generant particles. In such an arrangement, the squib is able to rapidly ignite the igniter powder which in turn causes the rapid ignition of the gas generant material.

In practice, the packaging of such igniter materials can be relatively simple and straightforward such as by packaging the igniter material in a small canister, such as an aluminum canister, in the center of a toroidal-shaped driver inflator or relatively complex such as by packaging the igniter material in a tubular device which in turn is inserted down a bore of a stack of gas generant wafers in a

typical, cylinder-shaped passenger inflator device. Regardless of the specifics of such designs, the packaging of a powder igniter material within an inflator device has typically required the inclusion of additional parts and added weight as well as increased assembly and manufacture expense.

In an alternative approach, an igniter composition may be applied or coated onto the surface of a gas generant material. For example, an igniter composition may be applied to an outer surface of a gas generant material in the form of a wafer or tablet such as by spraying the igniter composition onto the wafers or tablets or by dipping the tablets or wafers in a bath of the igniter composition. Regardless of the specifics of the application process, coating of the gas generant material has typically required increased manufacture expense and quality control to ensure even and adequate coverage of the wafers or tablets with the igniter composition.

Another approach has been to press the igniter material into a particle shape with similar dimensions as the gas generant particles and to strategically position these igniter particles within the gas generant mass in close proximity to the squib. Specific examples of this approach include: igniter material wafers placed or positioned at the end of a gas generant wafer stack next to a squib or placed with regular periodicity along the length of a gas generant wafer stack; igniter material tablet(s) placed or positioned at the squib end of a bed of gas generant tablets in a side

impact inflator; igniter material tablets placed down the bore of a gas generant wafer stack; igniter material tablets placed in the center of a bed of gas generant tablets in a toroidal driver inflator; or other similar concepts. Unfortunately, pressed igniter particles typically present a greatly reduced surface area as compared to a similar mass of igniter powder. As will be appreciated, a reduced surface area of the igniter material during combustion will typically result in a reduced rate of energy release and may, thus, cause or result in undesired ignition delays within an airbag inflator device. Moreover, such pressed igniter materials may be brittle and therefore prone to breakage or disintegration over time particularly if exposed to shocks, vibrations and/or thermal variations. Such breakage or disintegration may in turn result in the migration of the igniter material away from the squib and/or gas generant material resulting undesirable delays in ignition time.

In view of the above, there is a need and a demand for a resilient igniter substance that is resistant to breakage and has dimensions similar to those of a gas generant particle and also provides or results in a surface area similar to those of powdered igniter materials.

SUMMARY OF THE INVENTION

A general object of the invention is to provide an improved igniter substance and related methods of making such an igniter substance.

A more specific objective of the invention is to overcome one or more of the problems described above.

The general object of the invention can be attained, at least in part, through a foamable igniter composition effective to form a foamed igniter substance, including a fluoropolymer binder oxidant, a plasticizer effective to render the fluoropolymer binder oxidant flexible, a metal fuel that is reactive with the fluoropolymer oxidant, a blowing agent effective to render the foamable igniter composition porous, and a crosslinking agent effective to structurally stabilize the foamed igniter substance, wherein, upon being heated to a predetermined temperature, the foamable igniter composition forms the foamed igniter substance.

The prior art generally fails to disclose a foamed igniter substance that has dimensions similar to those of gas generant particles and that, when in active use, provides or results in a surface area similar to those of powdered igniter materials. The prior art further generally fails to disclose a foamable igniter substance that can be extruded or molded and which, upon being heated to a predetermined temperature, can form a foamed igniter substance having a predetermined shape. Moreover, the prior art generally fails to disclose a foamable igniter composition that may be applied to a surface and, upon being heated to a predetermined temperature, form a foamed igniter coating having improved resilience and shock resistance.

The invention further comprehends a method of making a foamed igniter substance including heating a foamable igniter composition containing a fluoropolymer binder oxidant, a plasticizer effective to render the fluoropolymer oxidant flexible, a metal fuel that is reactive with the fluoropolymer oxidant, a blowing agent effective to render the foamable igniter composition porous, and a crosslinking agent effective to structurally stabilize the foamed igniter substance to a temperature effective to at least partially decompose the blowing agent and foam the igniter composition, and crosslinking the foamed igniter composition to form a foamed igniter substance.

The invention still further comprehends a foamable igniter composition including:

about 10 to about 60 composition weight percent of a fluoropolymer binder oxidant;

about 1 to about 40 composition weight percent of a plasticizer effective to render the fluoropolymer binder oxidant flexible;

about 10 to about 50 composition weight percent of a metal fuel that is reactive with the fluoropolymer binder oxidant;

about 0.1 to about 30 composition weight percent of a blowing agent effective to render the foamable igniter composition porous; and

about 0.5 to about 5 composition weight percent of a crosslinking agent effective to structurally stabilize the foamed igniter substance;

wherein upon being heated to a predetermined temperature, the foamable igniter composition forms the foamed igniter substance.

The invention additionally comprehends, in accordance with one preferred embodiment, a damper pad cushion for use in an automotive airbag inflator formed from a foamable igniter composition. In accordance with another preferred embodiment, the invention further comprehends a hybrid gas storage container including a foamed igniter substance adhered to an inner surface of the container. The invention still further comprehends, in accordance with yet another preferred embodiment, a foamed igniter substance having predetermined shape such as, for example, a cylindrical or stick shape formed from an extruded foamable igniter composition.

Other objects and advantages will be apparent to those skilled in the art from the following detailed description taken in conjunction with the appended claims and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side sectional view of a single stage inflator device including a damper pad cushion formed from a foamable igniter composition.

FIG. 2 is a side sectional view of a single stage hybrid inflator device including a foamed igniter substance coating on an interior surface, in accordance with one embodiment of the invention.

FIG. 3 is a side sectional view of a single stage passenger inflator device including a cylindrical igniter stick formed from a foamable igniter composition, in accordance with one embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

The present invention provides a foamable igniter composition for use in an inflator device of an inflatable restraint system. More particularly, the present invention provides a foamable igniter composition that, upon being heated to a predetermined temperature, forms a foamed igniter substance.

In accordance with the invention, a foamable igniter composition includes: a fluoropolymer binder oxidant; a plasticizer effective to render the fluoropolymer oxidant binder flexible; a metal fuel that is reactive with the fluoropolymer binder oxidant; a blowing agent effective to render the foamable igniter composition porous; and a crosslinking agent effective to structurally stabilize the foamed igniter composition. Generally, upon being heated to a predetermined temperature, the foamable igniter composition is foamed and crosslinked to form a foamed igniter substance. Suitably, upon being heated to a predetermined

temperature, the foamable igniter material is foamed and crosslinked to form a resilient foamed igniter substance that is resistant to breakage or disintegration and, thus, retains a desirable shape and surface area to provide effective ignition of an associated gas generant material.

Generally, it is desirable that the fluoropolymer binder oxidant is sufficiently reactive with the metal fuel to effect efficient combustion of a foamed igniter substance formed or resulting from the subject foamable igniter composition. Moreover, it is desirable that the fluoropolymer binder oxidant be crosslinkable in order to effectively structurally stabilize a foamed igniter substance formed by or resulting from the subject foamable igniter composition. Advantageously, the fluoropolymer binder oxidant additionally imparts adhesive properties to the foamable igniter composition effective to adhere a foamed igniter substance formed by or resulting from the subject igniter composition to an associated surface.

Various fluoropolymers binder materials have been found to be suitable for use as an oxidant in the foamable igniter compositions of the present invention. One such fluoropolymer binder material includes a fluoropolymer elastomer material such as those available, for example, from DuPont Dow Elastomers L.L.C. under the registered trademark VITON. More particularly, fluoropolymer binder oxidants suitable for use in the foamable igniter composition include dipolymers of vinylidene

fluoride and hexafluoropropene, terpolymers of vinylidene fluoride, hexafluoropropene and tetrafluoroethene, and combinations thereof. In accordance with certain preferred embodiments, the foamable igniter composition includes a dipolymer of hexafluoropropene and vinylidene fluoride.

Typically, the foamable igniter composition includes the fluoropolymer binder oxidant in an amount effective to ensure complete combustion of the composition. Suitably, the foamable igniter composition includes about 10 to about 60 composition weight percent of the fluoropolymer binder oxidant.

Various plasticizers effective to render the fluoropolymer binder oxidant flexible may be utilized in accordance with the present invention. Suitable plasticizers include fluorocarbon oils. One particularly suitable plasticizer is polytrifluorochloroethylene.

Generally, the foamable igniter composition includes the plasticizer in an amount effective to render the fluoropolymer binder oxidant flexible. Typically, the foamable igniter composition contains about 1 to about 40 composition weight percent of the plasticizer.

The foamable igniter composition also includes a metal fuel that is reactive with the fluoropolymer binder oxidant. Generally, it has been found that some metals can react with fluoropolymer materials thereby forming metal fluorides and liberating relatively large quantities of heat. Such fluoropolymer-reactive metals

include, but are not limited to, aluminum, barium, beryllium, boron, calcium, lithium, sodium, strontium, titanium, zirconium and certain mixture or alloys thereof. In the practice of the present invention, suitable fluoropolymer-reactive metal fuels include aluminum, magnesium, alloys of aluminum and magnesium, and combinations thereof. In accordance with certain preferred embodiments, the fluoropolymer-reactive metal fuel is magnesium metal.

Typically, the foamable igniter composition of the invention contains an amount of fluoropolymer-reactive metal fuel effective to result in efficient ignition of an associated gas generant material. More particularly, the foamable igniter composition of the invention includes about 10 to about 50 composition weight percent of a metal fuel that is reactive with the fluoropolymer binder oxidant.

The foamable igniter composition of the invention also preferably contains a blowing agent effective to render the foamable igniter composition porous. Advantageously, the blowing agent may be provided in a particulate, solid or liquid form. Suitable blowing agents for use in the practice of the invention generally include those blowing agent materials that decompose to a gaseous species when subjected to heat. In practice those blowing agents that at least partially thermally decompose into gas at temperatures below the autoignition temperature of the associated igniter composition are preferred. Typically, such decomposition temperatures are less than 350°C such that the foamed igniter substance is required

to only be heated to a temperature below 350°C. Those blowing agents that at least partially decompose between 100°C and 300°C are believed to be the most useful and desirable in the practice of the invention to render the foamable igniter composition porous.

Furthermore, while the use of a blowing agent that decomposes into all gaseous species is generally preferred, the broader practice of the invention is not necessarily so limited, provided, that any resulting solid decomposition products do not substantially inhibit the combustion of the foamable igniter composition or are otherwise detrimental. Examples of useful blowing agents that typically produce or result in only gaseous products include: aminoguanidine bicarbonate, ammonium oxalate, azodicarbonamide, ammonium carbonate, ammonium carbamate, ammonium bicarbonate, 4,4'-oxydibenzene hydrazide, p-toluene sulfonyl semicarbazide and organic acids. Other useful blowing agents that generally decompose to only gaseous products includes solvents such as, but not limited to, acetone, ethyl acetate, butyl acetate and amyl acetate. Additional useful blowing agents that generally decompose leaving some solids include: alkali and alkaline earth metal carbonates or bicarbonates, such as basic copper carbonate, metal ammine carbonates such as copper diammine carbonate, metal ammine salts of organic acid such as copper diammine oxalate, and metal salts of organic acids, for example. In accordance with

certain preferred embodiments, the blowing agent included in the foamable igniter composition is p-toluene sulfonyl semicarbazide.

In general, the invention can desirably be practiced such that the foamable igniter composition includes about 0.1 to about 30 composition weight percent of the blowing agent.

The foamable igniter composition further includes a crosslinking agent. Advantageously, the crosslinking agent is effective to structurally stabilize the foamed igniter substance such that the porous structure formed upon the decomposition of the blowing agent is retained within the foamed igniter substance. More particularly, the crosslinking agent advantageously reacts with the fluoropolymer binder oxidant to form chemical bonds or crosslinkages that cure the heated and blown foamable igniter composition into a porous foamed igniter substance. Desirably, such bonds or crosslinkages are resistant to fracture or breakage due to sudden shock or vibration during storage within an associated inflator device but are relatively readily fracturable upon combustion of the foamed igniter material thereby further increasing the surface area of the foamed igniter substance.

Generally, crosslinking agents that can structurally stabilize the foamed igniter substance without detrimentally affecting the desired performance of the foamed igniter substance are suitable for us in the present invention. However, in

accordance with certain preferred embodiments, the crosslinking agent includes at least one bi-functional crosslinking agent and at least one peroxide crosslinking agent. For example, the crosslinking agent may contain trimethylolpropane trimethacrylate bi-functional crosslinking agent alone or in combination with a peroxide crosslinking agent such as, for example, benzoyl peroxide.

In practice, the foamable igniter composition can include about 0.5 to about 5 composition weight percent of a suitable crosslinking agent. More particularly, the foamable igniter composition can contain about 0.5 to about 5.0 composition weight percent of a bi-functional crosslinking agent and about 0.5 to 5.0 composition weight percent of a peroxide crosslinking agent.

The foamable igniter composition may further include a supplemental oxidizer in an amount of up to about 65 composition weight percent. Suitable supplemental oxidizer materials in accordance with the certain preferred embodiments of the invention include one or more alkali and alkaline earth metal nitrites, nitrates, chlorates, and perchlorates, ammonium nitrate, ammonium perchlorate, transition metal oxides, hydroxides, carbonates, nitrates and perchlorates, and transition metal complex nitrates, nitrites, and perchlorates, for example.

The invention further comprehends a method for preparing a foamed igniter substance containing a foamable igniter composition as disclosed above. In particular, in accordance with certain preferred embodiments, a foamed igniter

substance can be formed by heating a foamable igniter composition of the invention, as described above, to a predetermined temperature effective to at least partially decompose the blowing agent and foam the igniter composition, and crosslinking the foamed composition to form the foamed igniter substance. Generally, the foamable igniter composition can be heated to a predetermined temperature of between about 160°C and about 200°C to at least partially decompose the blowing agent and render the igniter composition porous.

Depending upon the desired end use, prior to heating, the foamable igniter composition may be: applied onto a surface to be coated by the foamed igniter substance; extruded into a predetermined shape; or loaded into a mold having a desired configuration wherein pressure is applied during the heating, for example.

In practice, the foamable igniter composition of the invention can be prepared by mixing a precursor solution including a fluoropolymer binder oxidant, a plasticizer and at least one crosslinking agent such as a bi-functional crosslinking agent with a precursor blend including a metal fuel reactive with the fluoropolymer binder oxidant and a blowing agent. Suitably, the precursor solution may be prepared by solvating the fluoropolymer binder oxidant, the plasticizer and the crosslinking agent with a solvent such as, for example, acetone. Thereafter, the precursor blend may be added to solution and stirred to disperse the precursor blend in the precursor solution and form a foamable igniter composition.

Depending upon the desired end use of the foamable igniter composition part or substantially all of the solvent may be removed from the foamable igniter composition such as by sparging the mixture with a stream of air to achieve a desired consistency prior to heating, for example.

For example, in accordance with one preferred embodiment, the foamable igniter composition of the invention may be prepared such as by sparging the composition with a stream of air until substantially all of the solvent is removed and the resulting foamable igniter composition forms a granular material that may be molded into a desired shape such as by loading the granules into a mold and applying pressure during the heating. Such a foamable igniter composition may be used to form, for example, a foamed damper pad cushion such as for use in an inflator device to protect an associated gas generant material from deterioration or breakage due to exposure to vibrational energy or physical shocks.

In accordance with another embodiment, the foamable igniter composition of the invention may be prepared such as by sparging the composition with a stream of air until a desired amount of solvent is removed and the resulting foamable igniter composition has a consistency similar to that of a putty or paste material that may be extruded into a predetermined shape such as, for example, a cylindrical or stick shape.

In accordance with a further embodiment, the foamable igniter composition of the invention can be applied to a surface such as by spraying, dipping, rolling, brushing or the like. Thereafter, the foamable igniter composition may be heated to a predetermined temperature to form a foamed igniter substance coating.

As will be appreciated by one of skill in the art, the foamable igniter composition of the present invention can be utilized in a variety of inflator devices in a variety of manners. For example, a foamable igniter composition as disclosed above may be employed in a single stage inflator device to protect a gas generant material from breakage or disintegration due to vibration or shock.

Referring to FIG. 1, a single stage inflator device 110 has a generally cylindrical external outline and includes a housing 112 such as formed from two structural components, i.e., a lower shell or base portion 114 and an upper shell or diffuser cap portion 116, such as may desirably be appropriately joined or fastened together.

The housing 112 is configured to define a generally cylindrical chamber, here designated by reference numeral 118. The chamber 118 contains or houses a supply of gas generant material 120, such as composed of a pyrotechnic, such as is known in the art, in a desired selected form. A filter assembly 122 surrounds the gas generant material 120.

The inflator device 110 includes a retainer 124, a diffuser damper pad cushion 126 and a base damper pad cushion 128 which serve to prevent undesired rattle or contact of the gas generant material 120 within the inflator device 110. In practice and such as described above, the diffuser damper pad cushion 126 and/or the base damper pad cushion 128 can be composed of a foamable igniter composition that has been molded and heated under pressure to a predetermined temperature to form a foamed igniter substance.

The inflator device 110 further includes an igniter assembly, generally designated by reference numeral 130 such as in the form of an igniter squib 132 and a squib adapter or holder 134. Suitably, the igniter squib 132 is mounted to or mated with the housing 112 in a location within the chamber 118 via a mounting opening 136.

When actuated, the squib 132 causes or results in ignition of the foamed igniter substance of the diffuser damper pad cushion 126 and/or the base damper pad cushion 128. The products formed or resulting for such ignition are, through the designed configuration, in direct contact with the gas generant material 120 contained within the chamber 118 such as to result in the ignition and reaction of the gas generant material 120. The gases produced or formed by such reaction then pass out of the inflator device 110 into an associated airbag cushion (not shown).

As will be appreciated, the inflator assembly 110 eliminates the need for assembly elements such as an igniter cup, an igniter tube or the like. Such elimination, in practice, can favorably reduce one or more of assembly weight and size as well as improve performance dependability and thus significantly alter, i.e., reduce, costs such as associated with inflator assembly manufacture, installation and/or operation, for example.

In accordance with certain preferred embodiments, a foamable igniter composition as disclosed above can be utilized to form a foamed igniter substance applied to an interior surface of an inflator device. For example, referring to FIG. 2, a hybrid inflator assembly, generally designated by reference number 210, includes a foamable igniter composition applied to at least one interior surface thereof.

The hybrid inflator assembly 210 includes a pressure vessel 212 including a storage chamber 214. The storage chamber 214 is filled and pressurized with an inert gas such as, for example, argon, helium or nitrogen, or a reactive gas such as, for example, nitrous oxide to a pressure typically in the range of about 2000 psi to about 4000 psi. The hybrid inflator assembly also includes a diffuser 216 and an igniter assembly 218, such as may desirably be appropriately joined or fastened together. The diffuser 216 includes a burst disk 240 which serves to seal the gases contained in the storage chamber 214 from the diffuser 216.

The hybrid inflator assembly 210 further includes a fill port 220 used for gas pressurization, which is integral to the pressure vessel 212 and which, after pressurization, is appropriately sealed such as with a ball weld 222.

The hybrid inflator assembly 210 additionally includes a foamed igniter substance coating 224 in contact with at least a portion of the interior of the pressure vessel 212. In practice and such as described above, a foamable igniter composition in accordance with the invention is desirably applied to at least a portion of a selected interior surface of the pressure vessel 212 and thereafter heated to predetermined temperature to form the foamed igniter substance coating 224.

The igniter assembly 218 includes an igniter squib 226 and a squib adapter or holder 228. Suitably, the squib adapter 228 is mounted to or mated with the igniter assembly 218 via a mounting opening 230. Also included in the igniter assembly 218 is a pyrotechnic charge 232 housed within a container 234 adjacent to an orifice 236, which is sealed by a burst disk 238 attached to the igniter assembly 218.

When actuated, the igniter squib 226 ignites the pyrotechnic charge 232 contained within the container 234. The pyrotechnic charge 232 produces reaction products including a hot flame and gas in a quantity sufficient to burst the container 234 and the burst disk 238. The released gas and hot flame travel through the orifice 236 causing ignition of the foamed igniter substance coating 224. The

products formed or resulting from such ignition are brought, through the designed configuration, in direct contact with the gas or gases contained in the storage chamber 214. The subsequent heating of these gases raises the pressure inside the storage chamber 214 to a level sufficient to break the burst disk 240. The heated gases are thereby released into the diffuser 216 and pass out of the hybrid inflator assembly 210 into an associated airbag cushion (not shown).

As will be appreciated by one of skill in the art and guided by the teachings herein, the hybrid inflator assembly 210 eliminates the need for gas heater assembly elements such as a gas generant cup and associated hardware. Such elimination, in practice, can favorably reduce one or more of assembly weight and size as well as improve performance dependability and thus significantly alter, i.e., reduce, costs such as associated with inflator assembly manufacture, installation and/or operation, for example.

In accordance with an additional preferred embodiment, a foamable igniter composition as disclosed above can be utilized to form a foamed igniter substance having a predetermined shape, such as a cylindrical or stick shape. For example, referring to FIG. 3, a airbag inflator 310 includes an elongate, generally cylindrical housing 312 formed of a metal such as steel or aluminum and provided with a cylindrical sidewall 314 having a plurality of gas ports or perforations 316

spaced apart around the surface at appropriate intervals for discharging gas to inflate an associate airbag (not shown) when the inflator 310 is activated.

The housing 312 is closed at one end with an integral, circular end wall 318 having a centrally located outwardly projecting mounting pin 320 for use in securing the inflator 310 in an appropriate selected position such as behind an instrument panel or dashboard of a motor vehicle, for example. At an opposite end, the housing 312 is closed with an annular, circular end wall 322 having a central aperture for receiving an ignition squib 324 for initiating the gas generating process to inflate an associated airbag cushion. The annular end wall 322 is held in place to close the housing 312 by an annular, deformed end flange 326 formed in a metal crimping, rolling or inertia weld process after all of the interior components of the inflator 310 are assembled in place.

Inflation gas is rapidly generated, by the ignition and combustion of a plurality of washer-like, annular gas generant wafers 328 arranged in an elongated cylindrical stack 329 contained within the housing 312 and extending between the opposite end walls 318 and 322. The wafers 328 are formed of solid material such as sodium azide or other type of gas generant material, which produces a large volume of relatively inert gas when the wafers are ignited. Each wafer 328 includes a central opening 330 or core passage which forms a short segment of an elongated, central core passage 332 which extends through the stack 329 of wafers contained in the

housing 312 between the opposite end walls 318 and 322. The wafers 328 at opposite ends of the stack 329 are maintained in spaced apart relation to the adjacent housing end walls 318 and 322 by means of annular spacers 334 and 336. The spacers 334 and 336 are formed with respective central cores or passages 334a and 336a, which form opposite end segments of the elongated central passage 332 formed by the wafers 328.

The cylindrical stack 329 of solid gas generant wafers 328 is surrounded by an elongated, hollow tubular filter 338 for cooling the hot gas generated upon reaction of the gas generant wafers 328 and filtering out hot particulates that might otherwise pass out through the gas discharge ports 316 and cause damage to the inflating airbag and immediate environs. The filter 338 may be formed from several layers 340 of metal screen materials or other type of filter media. The inside surface of the housing side wall 314 is sealed with a thin layer of adhesively applied metal foil 342 so that the gas ports 316 are sealed off and the interior of the housing 312 is protected from the entry of contaminants for the exterior. The metal foil 342 is readily ruptured by the gas pressure within the housing 312 when the gas generant wafers 328 are ignited so that the generated gas flows freely out through the gas discharge ports 316 to inflate the associated airbag cushion.

In accordance with the present invention a foamed igniter substance 346 is located within the elongated central core passage 332. The foamed igniter

substance 346, having a predetermined shape such as, for example, a cylindrical or stick shape, may be placed within the elongated central core passage 332 adjacent the ignition squib 324. For example, in accordance with certain preferred embodiments the foamed igniter substance 346 may be placed within the elongated central core passage 332 adjacent and in contact with the ignition squib 324. In accordance with another preferred embodiment, such as shown in FIG. 3, the foamed igniter substance 346 may be placed in the central core passage 332 adjacent and suitably spaced apart from the ignition squib 324.

When the squib 324 is activated, the foamed igniter substance 346 is ignited causing the gas generant wafers to ignite thereby initiating production of inflation gas. The inflation gas produced by such ignition then passes out of the inflator into an associated airbag cushion (not shown).

As will be appreciated, the inflator assembly 310 eliminates the need for assembly elements such as an igniter tube, a rapid deflagration or RDC cord, or the like. Such elimination, in practice, can favorably reduce one or more of assembly weight and size as well as improve performance dependability and thus significantly alter, i.e., reduce, costs such as associated with inflator assembly manufacture, installation and/or operation, for example.

The present invention is described in further detail in connection with the following example which illustrates or simulates various aspects involved in the

practice of the invention. It is to be understood that all changes that come within the spirit of the invention are desired to be protected and thus the invention is not to be construed as limited by this example.

EXAMPLE

A foamable igniter composition in accordance with the invention and as shown in TABLE 1, below, was prepared by solvating a fluoropolymer binder oxidant which was a copolymer of vinylidene fluoride and hexafluoropropene, available under the registered trademark VITON A from DuPont Dow Elastomers L.L.C., and a plasticizer including polytrifluorochloroethylene with an equal weight of acetone to form a solution. A bi-functional crosslinking agent containing trimethylolpropane trimethacrylate was then added to the solution to form a precursor polymer solution. Dry ingredients including magnesium metal fuel, p-toluene sulfonyl semicabazide blowing agent and benzoyl peroxide crosslinking agent were mixed to form a precursor blend. The precursor blend was thoroughly mixed into the precursor polymer solution to form a foamable igniter composition.

The foamable igniter composition as prepared above had the following properties or characteristics as shown in TABLE 2, below.

TABLE 1		
Ingredient	**Function**	**Comp Wt. %**
VITON A binder	Oxidant	50.4
Polytrifluorochloroethylene	Plasticizer	10.1
Magnesium metal	Fuel	35.7
p-toluene sulfonylsemicarbazide	Blowing agent	0.3
Trimethylolpropane trimethacrylate	Bi-functional crosslinking agent	1.0
Benzoyl peroxide	Peroxide crosslinking agent	2.5
TOTAL		100.0

TABLE 2	
Property	
Heat of Reaction	920 cal/gram
Flame temperature	3000 K
Gas yield	1.6 moles/100 grams

The major combustion products produced by ignition of the above foamable igniter composition include carbon, magnesium fluoride and hydrogen. Because such combustion products are fuel rich, the foamed igniter substance of the invention may be advantageously combined with an underfueled gas generant material or a supplemental oxidizer such as oxygen or nitrous oxide in a hybrid inflator assembly to desirably increase the energy output.

Thus, the invention provides a foamable igniter composition that may be heated to a predetermined temperature to form a foamed igniter substance that may be utilized in an inflator device for an inflatable restraint device. More particularly, the present invention provides a foamable igniter composition that may be heated to a predetermined temperature to form a porous foamed igniter substance having dimensions similar to that of an associated gas generant material and a surface area comparable to a powdered igniter material. Additionally, the invention provides a foamable igniter composition that may be extruded or molded to form a foamed igniter substance having a predetermined shape such as that of a damper cushion pad. The invention further provides a foamable igniter composition that may be applied to a surface to form a foamed igniter coating.

The invention illustratively disclosed herein suitably may be practiced in the absence of any element, part, step, component, or ingredient which is not specifically disclosed herein.

While in the foregoing detailed description this invention has been described in relation to certain preferred embodiments thereof, and many details have been set forth for purposes of illustration, it will be apparent to those skilled in the art that the invention is susceptible to additional embodiments and that certain of the details described herein can be varied considerably without departing from the basic principles of the invention.